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Method for the air conditioning of a vehicle interior as a function of incident solar radiation

The invention relates to a method for the air conditioning of a vehicle interior as a function of incident solar radiation according to the preamble of claim 1.

DE 40 24 431 A1 discloses an air conditioning system with an incident solar radiation sensor arrangement having a plurality of sensor elements. In this case, first, the intensity and direction of the incident solar radiation are determined from the individual sensor output signals, after which these two variables serve for controlling an air conditioning system and further vehicle-side assemblies.

Also in a circuit arrangement, known from DE 43 05 446 A1, which comprises an incident solar radiation sensor arrangement having a plurality of sensor elements, first the intensity and direction of the incident solar radiation are determined from individual sensor element output signals, after which these two variables serve for controlling an air conditioning system and further vehicle-side assemblies.

US 4,760,772 likewise discloses an air conditioning system with an incident solar radiation sensor arrangement having three sensor elements, of which one is assigned to the vehicle front region and the other two are assigned to the two vehicle side regions lying behind this, or having four sensor elements, of which one is assigned to the vehicle front region, one is assigned to the vehicle rear region and the other two

are assigned to the two vehicle side regions, in each case the intensity and direction of the incident solar radiation being determined from the sensor element output signals by means of a following computer unit, so that the air conditioning capacity of the air conditioning system can be set differently for various vehicle interior regions by means of these two calculated variables.

In US 5,186,682, as in US 4,760,772, the signal from two lateral incident solar radiation sensors of a common air conditioning unit is evaluated in terms of the intensity and direction of incidence of the sunlight. The single air conditioning controller unit then activates the existing air conditioning ducts as a function of the determined intensity and direction of the incident solar radiation.

Finally, DE 195 44 893 C2 discloses an air conditioning system for the air conditioning of a vehicle interior as a function of incident solar radiation, with at least two air conditioning ducts of individually controllable air conditioning capacity for the air conditioning of different vehicle interior regions, and with an incident solar radiation sensor arrangement having a plurality of sensor elements for detecting the incident solar radiation in different solid angle ranges. Each air conditioning duct is individually assigned its own sensor element of the incident solar radiation sensor arrangement and its own air conditioning controller unit. The sensor element assigned in each case detects the incident solar radiation essentially with a restriction to that solid angle range which corresponds positionally to the vehicle interior region air-conditioned by the respective air conditioning duct. The air conditioning controller unit assigned in each case sets the air

conditioning capacity of the respective air conditioning duct as a function of the output signal from only the assigned sensor element of the incident solar radiation sensor arrangement.

Thus, by means of the prior art last mentioned, an individual air conditioning of various regions of the vehicle interior as a function of incident solar radiation is possible.

However, the incident solar radiation sensor arrangement supplies only the solar values of the individual zones and the average value of these. The solar value of the individual zones is in this case used directly as a factor characteristic curve for temperature or blower regulation as a function of the outside temperature, that is to say the blown-air temperature is lowered as a result of the Sun's influence or the blower level is raised. This does not allow for whether the Sun is high or low with respect to the vehicle.

When the Sun is very high, all the values of the sensor elements of the incident solar radiation sensor arrangement have approximately the same value. Depending on the strength of the incident radiation, the values are higher or lower. In complete darkness, the sensor values indicate 0%, while, in the case of very strong incident solar radiation, the sensor values indicate a maximum of 125%. In the case of a very high solar load and when the Sun is very high, this means, for air conditioning regulation, that, although there is no incident solar radiation acting on the vehicle occupants since the incident solar radiation takes place on the vehicle roof and not through a window into the interior, in all the zones the blow-out temperature is lowered very sharply or the blower fraction is

increased very sharply as a result of the incident solar radiation. This air conditioning regulation, however, is faulty and is very uncomfortable for the occupant/occupants.

The object of the present invention is, therefore, to develop the generic air conditioning system for the air conditioning of a vehicle interior as a function of incident solar radiation and a method for operating said air conditioning system, in such a way that the abovementioned faulty air conditioning regulation which is very uncomfortable for the occupant/occupants is eliminated.

This object is achieved, according to the invention, by means of a method for the air conditioning of a vehicle interior as a function of incident solar radiation having the features of claim 1. Advantageous developments of the invention are specified in the subclaims.

As a result of the calculation of the steepness of the sunlight or of the laterally specific incident solar radiation, it is possible, during automatic blower operation, to react to and counteract in a more focused manner the influencing factors/disturbing variables acting on the vehicle from outside, such as, for example, incident solar radiation from one side or steeply angled sunlight. The occupants, by manual action, can set the blower even more individually to their requirements. A marked improvement in air conditioning comfort is thereby achieved for the individual seat positions.

This and further objects, features and advantages of the present invention become obvious for the following description of a preferred exemplary embodiment of the

invention, in conjunction with the drawing in which:

Fig. 1 shows an illustration of the sunlight steepness calculated according to the invention and of a factor, assigned to respective sunlight steepness, for varying the air conditioning regulation.

According to the invention, the steepness of the sunlight is calculated by calculating the various solar values of the individual zones. The calculation of the sunlight steepness determines whether the incident solar radiation is acting on the occupants or not. With the aid of the sunlight steepness, a corresponding correction factor is determined, by means of which a highly accurate compensation of the blown-air temperature or of the blower increase due to the incident solar radiation is possible.

The method for calculating the sunlight steepness is described in more detail below. In this case, the explanation is made by the example of a four-zone air conditioning system, but may be applied likewise to other multizone air conditioning systems with more or fewer zones.

First, the incident solar radiation is detected in different solid angle ranges, using four sensor elements 1a to 1d, for example of a four-quadrant sensor. The sensor elements are in this case arranged in such a way that, for example, the first sensor element 1a detects the vehicle region at front right, the second sensor element 1b the vehicle region at front left, the third sensor element 1c the vehicle region at rear right and the fourth sensor element 1d the vehicle region at rear left and are assigned to corresponding air conditioning regions in the vehicle.

Thereafter, taking into account output signals A1 to A4 from the first to fourth sensor elements 1a to 1d and an arithmetic average value $\bar{A}$ emitted by the solar sensor, a sunlight steepness S is calculated.

This sunlight steepness S may be calculated, for example, according to the following formula:

$S = ((|A2 - A3| + |A1 - A4|) / 2 * M / \bar{A}$,

S being the sunlight steepness, A2 the output signal from a second sensor element 1b (FL), A3 the output signal from a third sensor element 1c (RR), A1 the output signal from a first sensor element 1a (FR), A4 the output signal from a fourth sensor element 1d (RL), M a multiplier and $\bar{A}$ the arithmetic average value of the output signals A1 to A4 from the first to fourth sensor elements.

The multiplier M amounts, for example, to 50 and is used in order to obtain a greater and therefore more easily illustratable value. The formula for calculating the sunlight steepness S is organized in such a way that S becomes the higher, the lower the angle of the incident solar radiation is. A Sun with a low angle of incident radiation and with a high value of sunlight steepness impinges upon more window areas and therefore requires more air conditioning and therefore higher air conditioning. Furthermore, by the sunlight steepness being calculated according to the invention, it is possible to reduce the probability of error, since, in the case of lower-angled incident radiation and therefore lower sensor output signals, the sunlight steepness becomes greater even in diffuse light, hazy weather and/or the brief effect of sunlight, and consequently minor errors cannot have such a great influence.

Subsequently, with the aid of the calculated sunlight

steepness S, a correction factor K is determined which is applied to the air conditioning regulation values, such as, for example, the blow-in temperature and/or the blower power, which are calculated by the use of the sensor values, conventionally using a four-quadrant sensor, as a rule the blow-in temperature being lowered and the blower power being raised. Fig. 1 shows the profile of a correction factor K of this type in relation to the sunlight steepness S calculated by means of the formula according to the invention. The profile of the correction factor K is in this case vehicle-dependent and design-dependent, since, for example, influences of varying magnitude occur on the occupants in the case of window areas or window tilts of different size.

It is evident from Fig. 1 that, below a first threshold value S1 of the sunlight steepness, for example 10, a constant low connection factor, 0.4 in the example, is used, since incident solar radiation is very steep from above here, but insignificant changes do not lead to any appreciable changes in the influence on the occupants. Consequently, to improve comfort, conventionally calculated air conditioning regulation values are multiplied by the correction factor 0.4, in order substantially to reduce the air conditioning variance due to the incident solar radiation, since, because of the high steepness, scarcely any influence is exerted on the occupants. Likewise, in a range above a second threshold value S2 of the sunlight steepness, for example 40, the correction factor selected is once again constant, since, with the very low-angle incident solar radiation on which this sunlight steepness is based, only insignificant changes in the angle of incidence occur and therefore require no further adaptation of the air conditioning regulation. In the example, in the case of this very low-angle incident

solar radiation and therefore high sunlight steepness above the second threshold value S2, the correction factor K is set at 1 and the air conditioning regulation values calculated, using the values of the four-quadrant sensor, are used, unchanged. In the range between these two threshold values S1 and S2, for example, a linear correction factor profile may be employed, as shown in Fig. 1.

Moreover, an adverse influence of cornerings on the air conditioning regulation is avoided by the sunlight steepness being determined according to the invention.

In summary, the present invention discloses a method for the air conditioning of vehicle interior as a function of incident solar radiation. In a vehicle with, for example, a four-zone air conditioning system, the incident solar radiation is detected by means of sensor elements assigned to the various air conditioning zones in the vehicle and is used for regulating the air conditioning capacity. In order to avoid faulty regulation due to a detected incident solar radiation which does not influence or only slightly influences the passengers because of perpendicular incident radiation, for example, on the roof, the hood and the trunk lid, the incident radiation direction is determined by means of a sensor element and the regulation of the air conditioning capacity is adapted correspondingly, so that the situation of too intensive cooling, for example in the case of perpendicular radiation on the vehicle roof, is avoided.